Spring 6-11-2013

Kinetic behaviour of biomass mixtures during torrefaction and steam gasification

Elvira Rodriguez
CEA

C. Dupont
CEA

D. Da Silva
CEA

Perez Labalette
CEA

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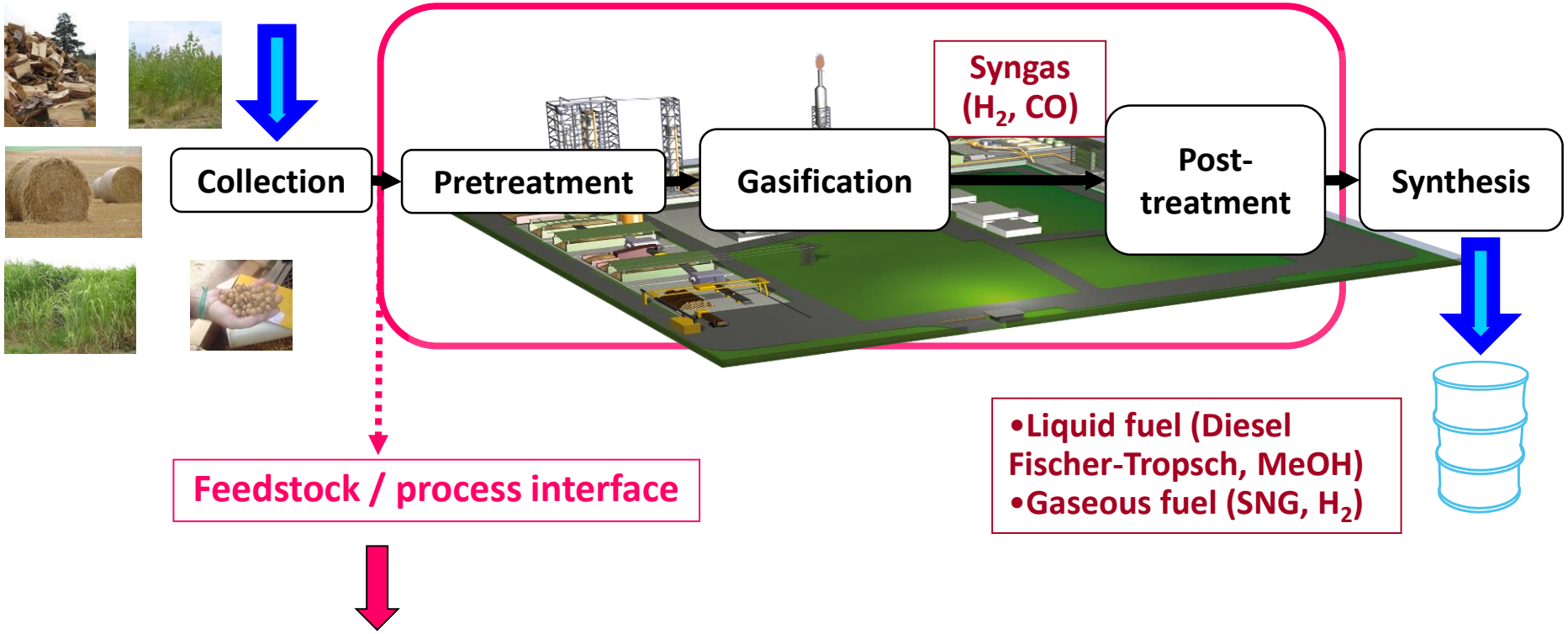
E. Rodriguez Alonso, C. Dupont, D. Da Silva Perez, F. Labalette

BIOENERGY IV CONFERENCE
Tuesday, 12th June 2013

The process: from biomass to fuel



Suitability is crucial for industrialization

Feedstock/process suitability

- To improve feedstock/process suitability → two issues:

➢ Quantity
  - Limited
  - Can vary along the year

➢ Quality
  - Properties intrinsically variable
  - Can vary along the year

SOLUTION?

A solution: biomass blends

Biomass blends

Reactor design

REQUIREMENT

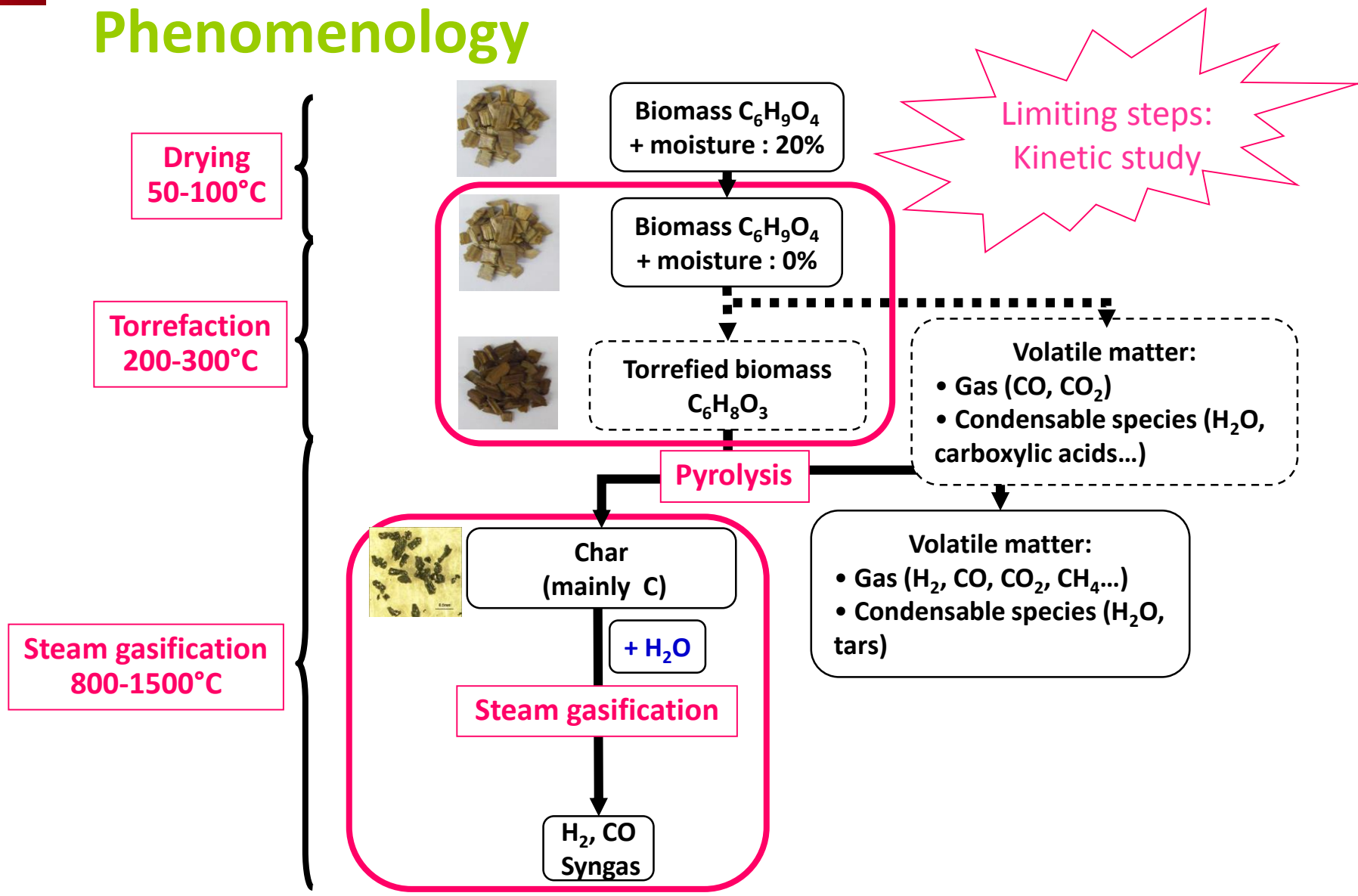
Feedstock thermal behaviour

Nevertheless… so far:

- No characterization
- No modelling

} of thermal behaviour of biomass blends

Phenomenology



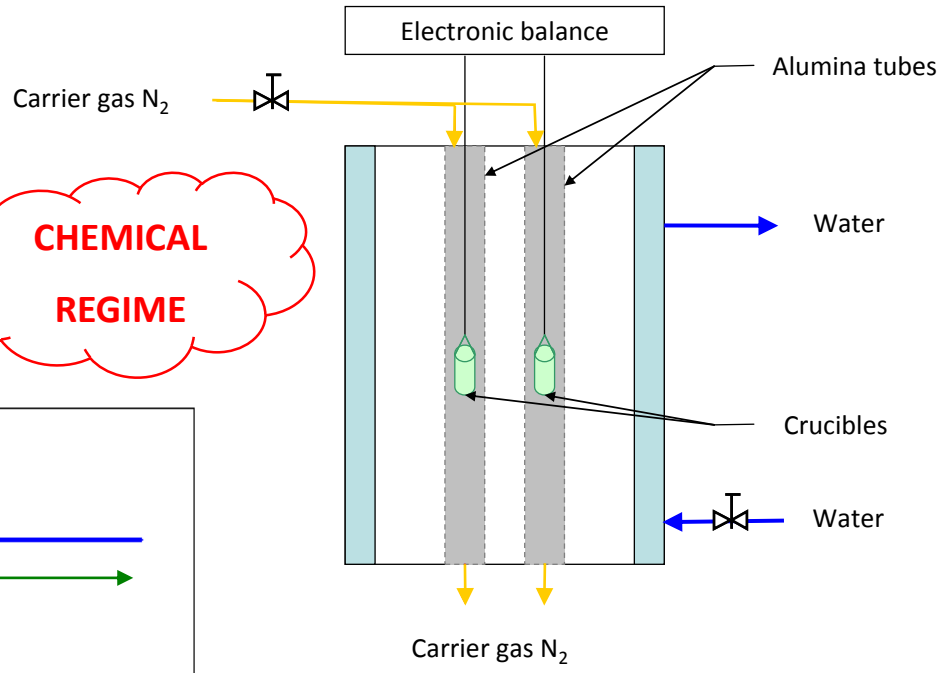
Objective and working plan

- Objective:
  - study biomass blends kinetics during torrefaction and steam gasification of char
  - check existence/lack of additive law

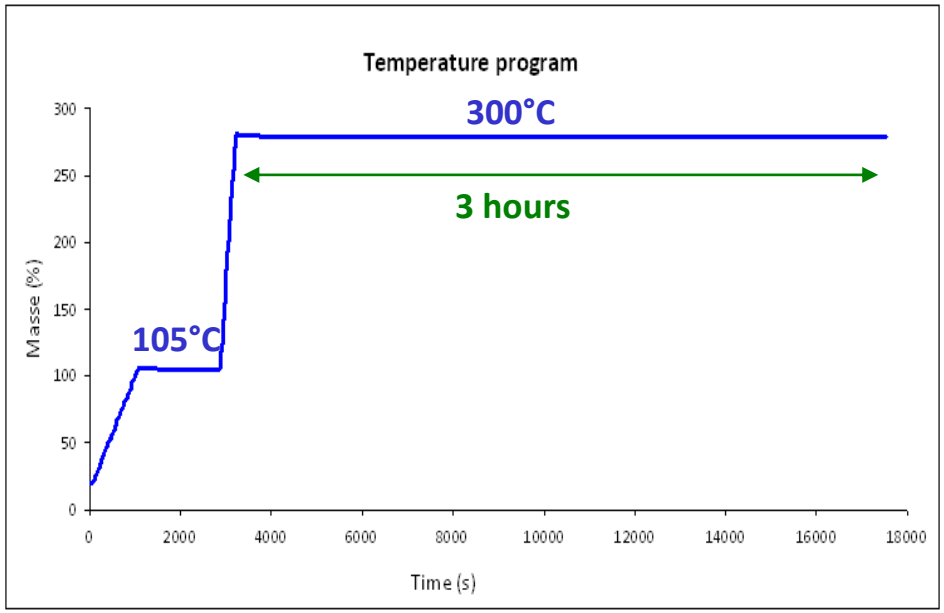
- Working plan:
  - Lab-scale experimentation → thermobalance
    - Torrefaction → non-reactive atmosphere
    - Steam gasification → reactive atmosphere
  - Kinetic modelling

Torrefaction: experimental device

Setaram TG-DSC 111

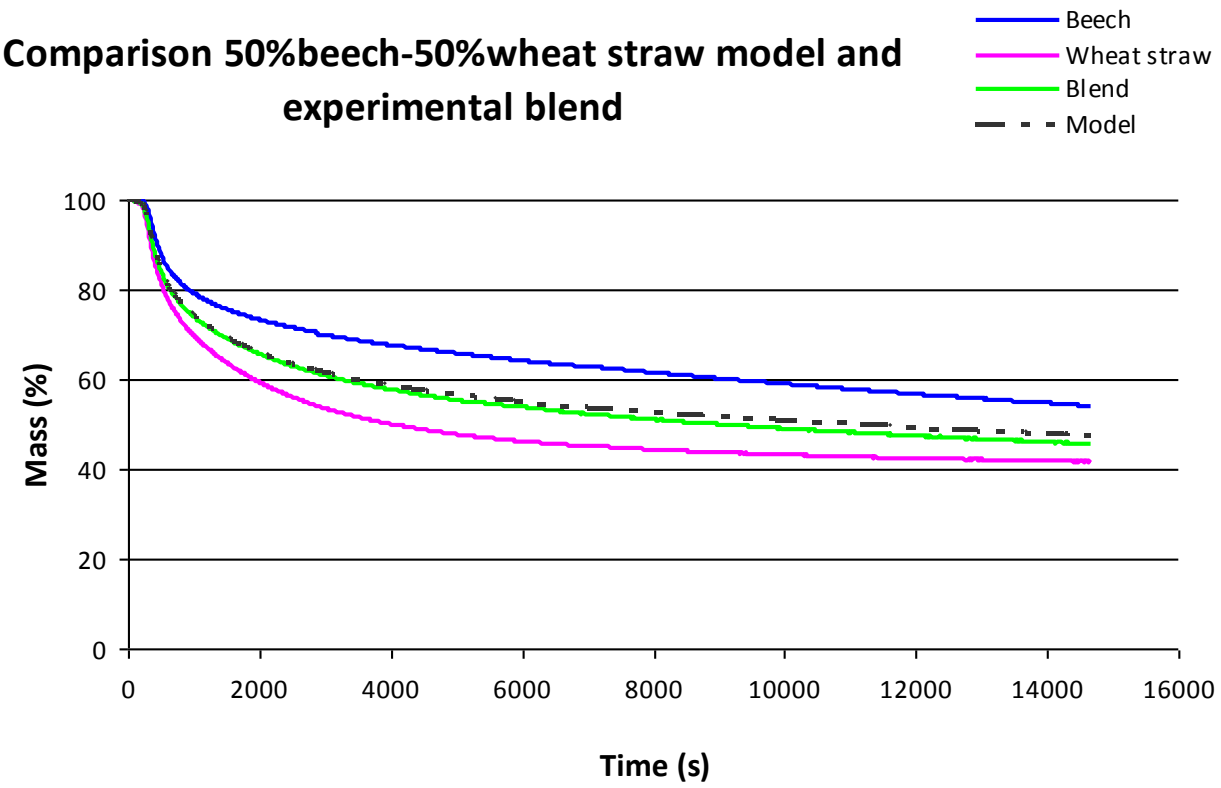


CHEMICAL REGIME



Sample nature	Beech/ wheat straw blend
Blend ratio	25/75, 50/50, 75/25
Sample mass	5 mg
Particle size	<200µm
Flow gas	N_2

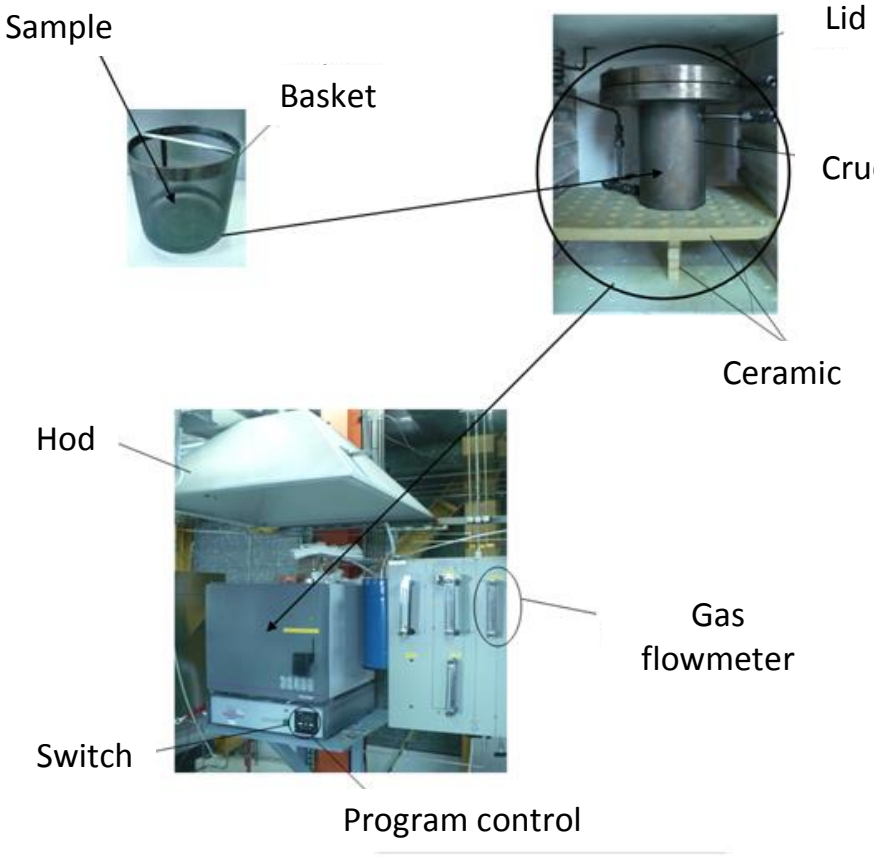
Torrefaction: kinetic modelling



$$\Delta m_{BLEND} = \Delta m_{BIOMASS\ 1} \cdot \%_{BIOMASS\ 1} + \Delta m_{BIOMASS\ 2} \cdot \%_{BIOMASS\ 2}$$

ADDITIVE LAW

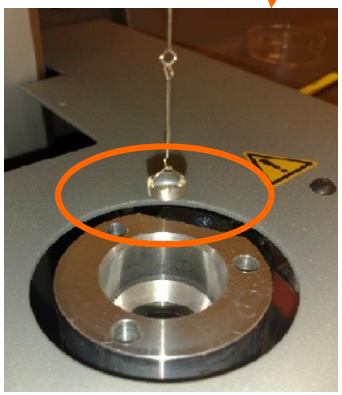
Steam gasification: experimental device

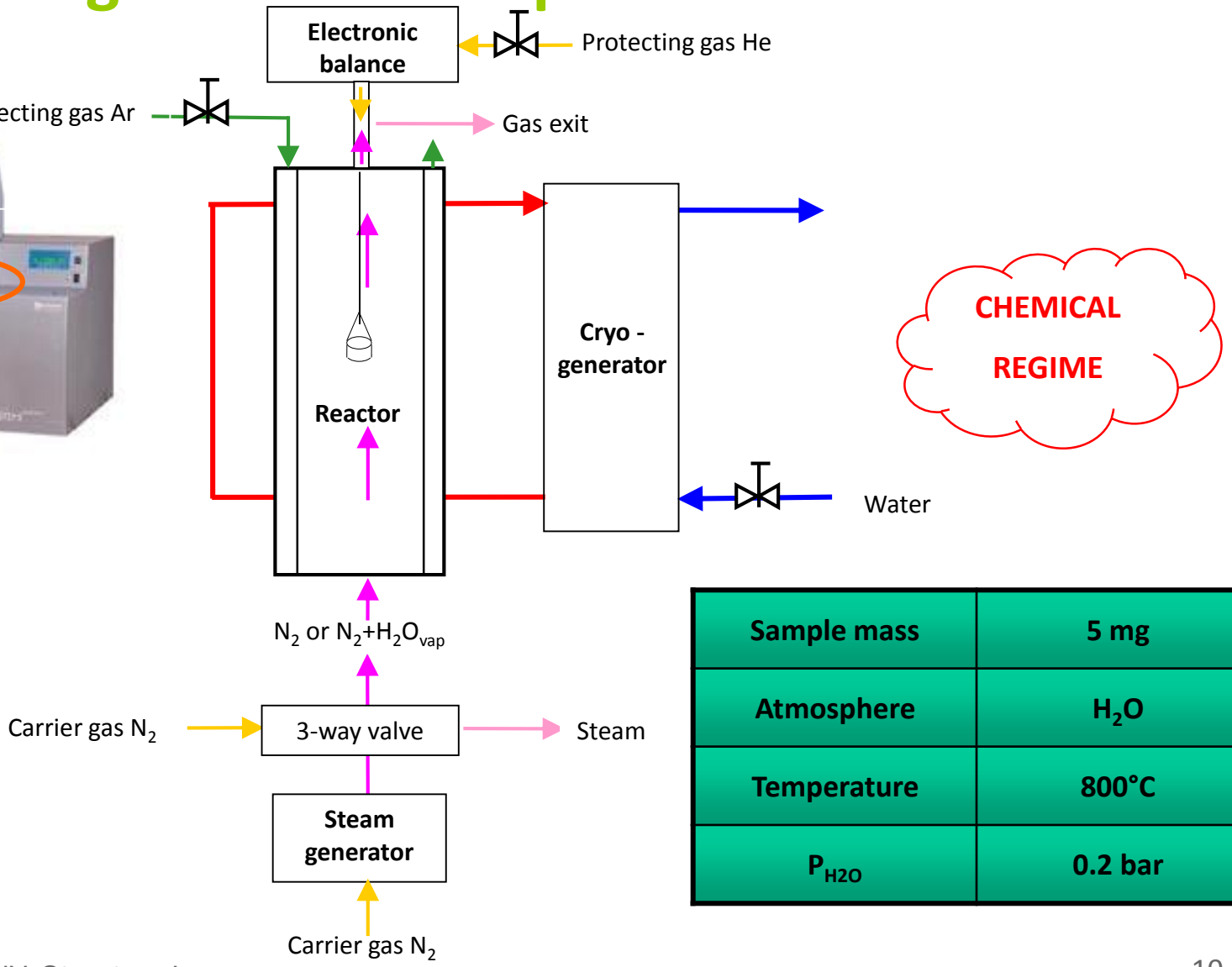


Slow pyrolysis

Sample nature	**Beech/ wheat straw blend**
Blend ratio	**25/75, 50/50, 75/25**
Temperature	**450°C**
Time	**4h**
Flow gas	**N_2**

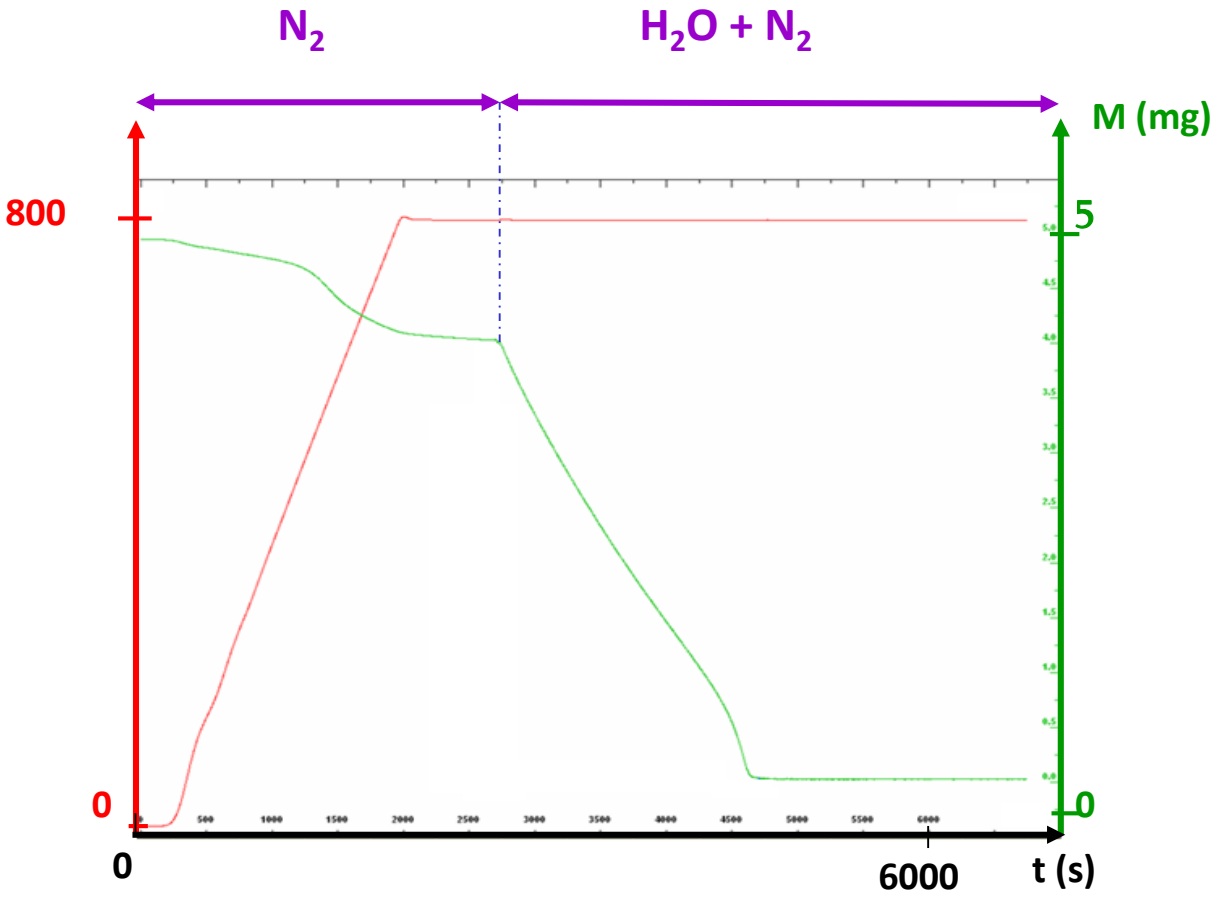
Steam gasification: experimental device



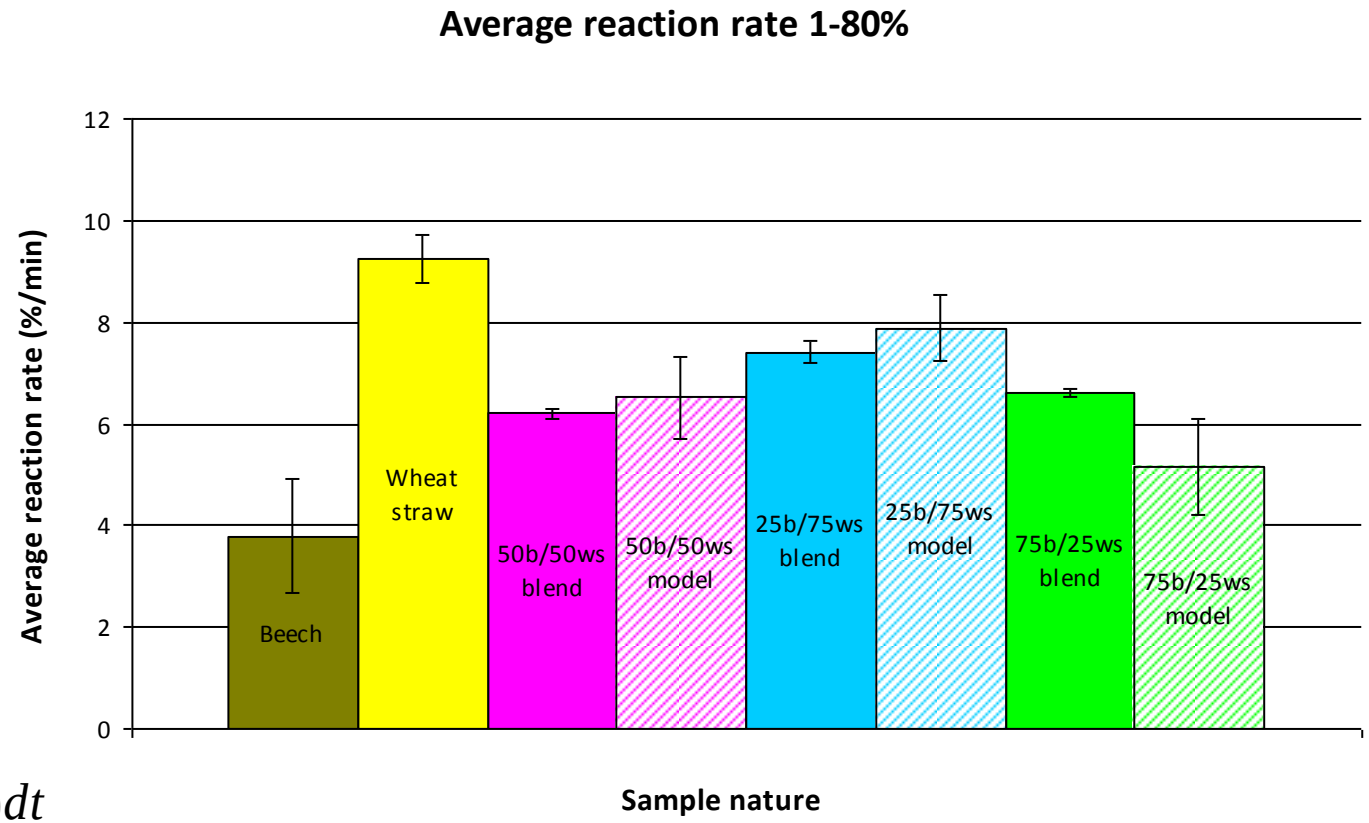


Sample mass	5 mg
Atmosphere	H_2O
Temperature	800°C
P_{H2O}	0.2 bar

Steam gasification: experimental device



Steam gasification: kinetic modelling

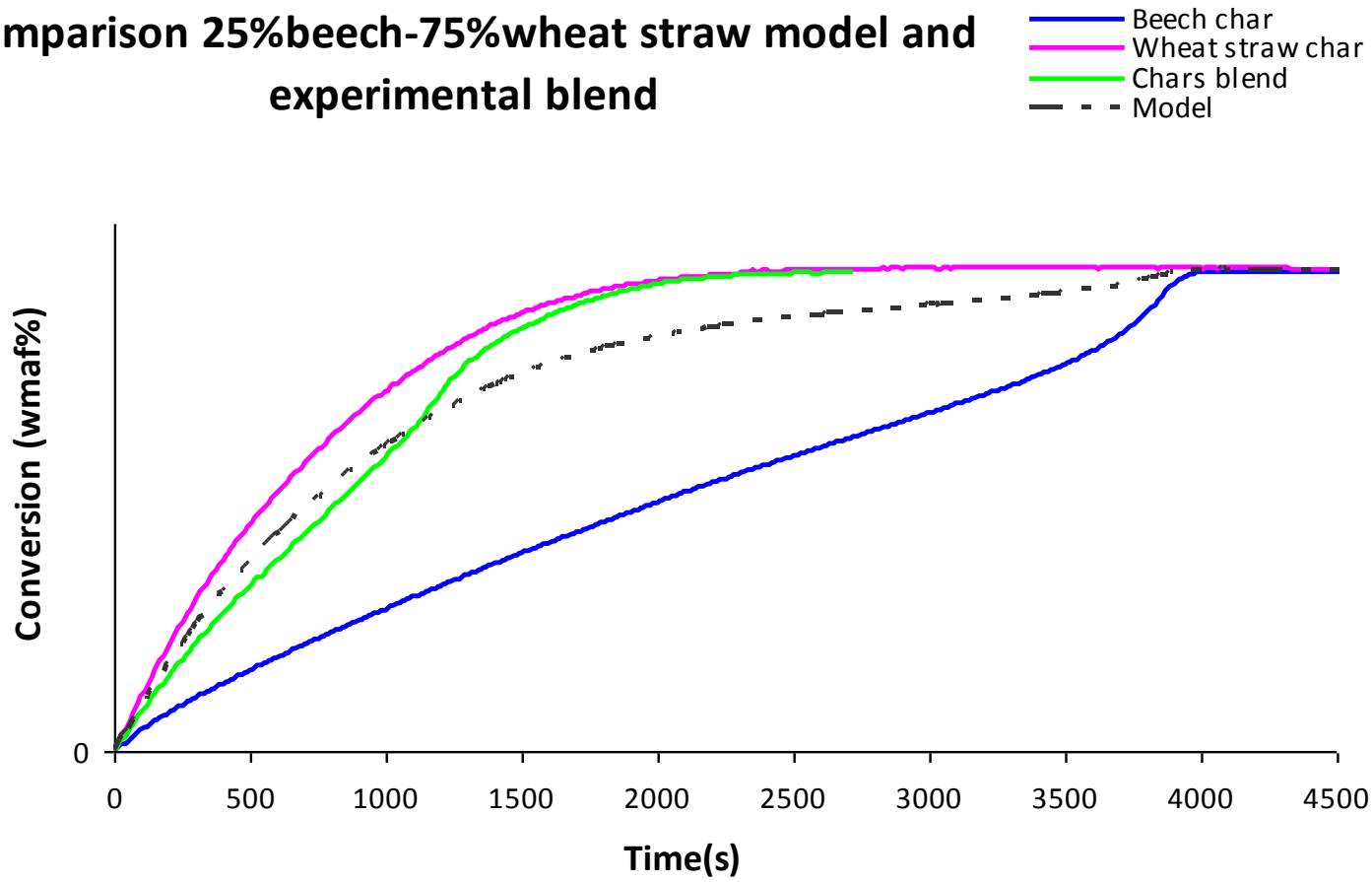


$$r_{1-80\%} = \frac{\int_{t_{X=0,01}}^{t_{X=0,80}} \frac{r(t)dt}{1-X(t)}}{t_{X=0,80} - t_{X=0,01}}$$

ADDITIVE LAW → globally valid… ✓

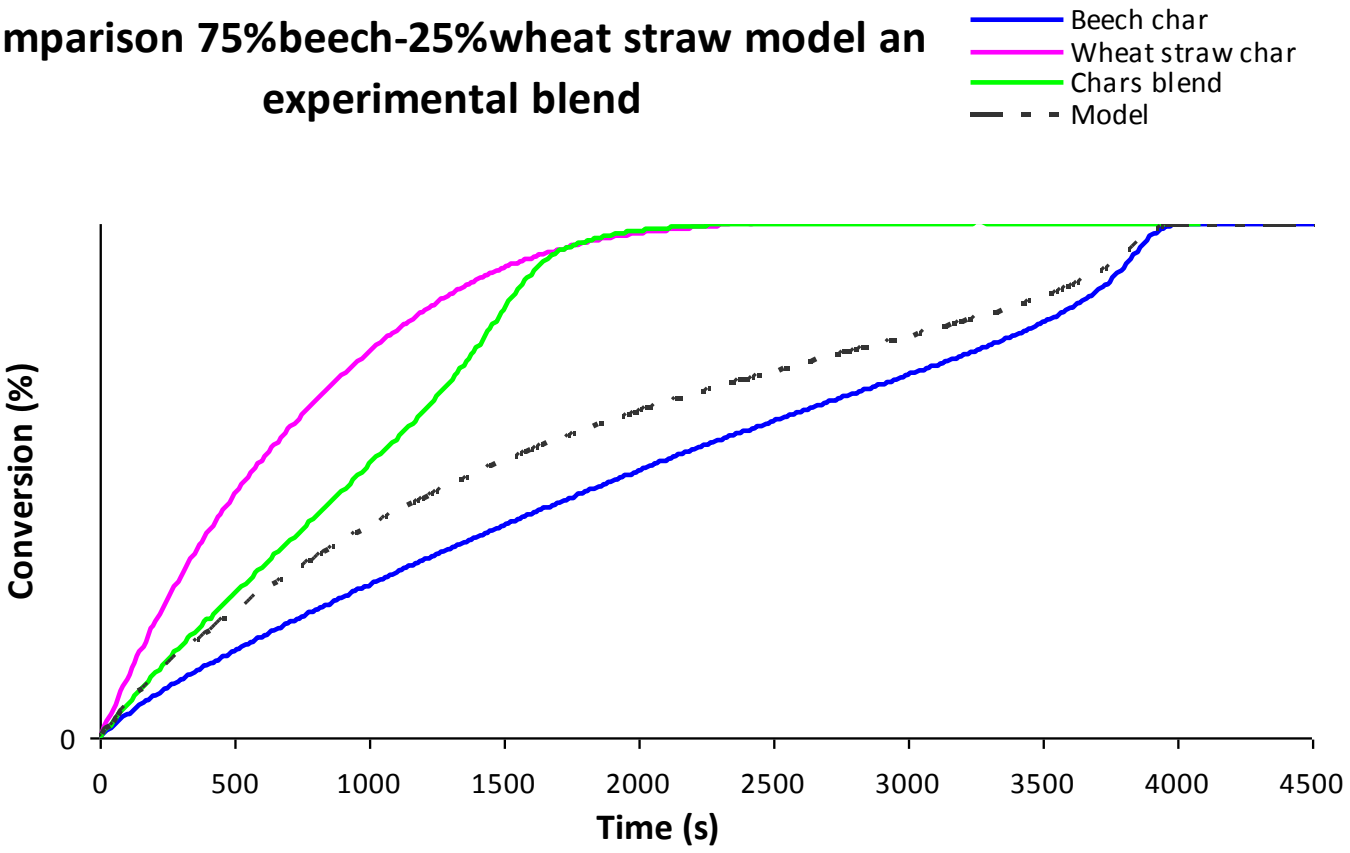
Steam gasification: kinetic modelling

Comparison 25%beech-75%wheat straw model and experimental blend



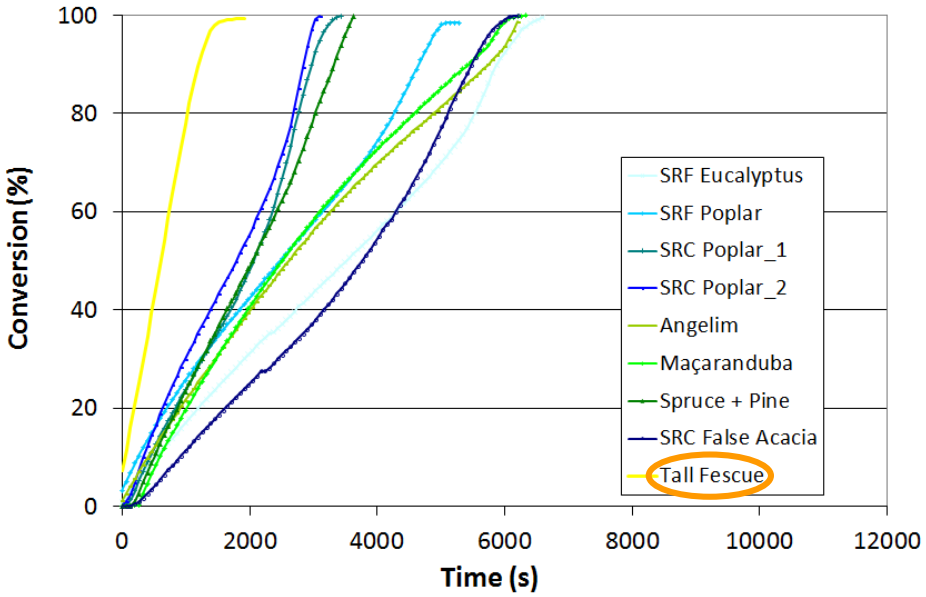
…but in detail → ADDITIVE LAW

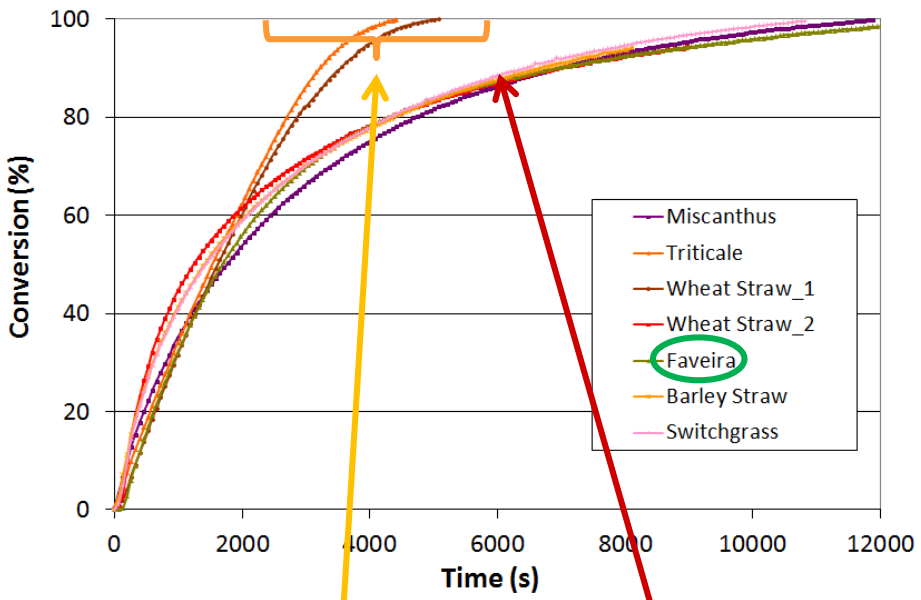
Steam gasification: kinetic modelling



ADDITIVE LAW

Steam gasification: kinetic modelling





Rate evolution	Tall Fescue	Faveira	Agricultural biomass
At low conversions	Constant	Constant	Moderate decrease
At high conversions	Increase	Moderate decrease	Strong decrease
	Wood	Wrong!	Agricultural biomass

Steam gasification: kinetic modelling

Experimental curve is accelerated comparing to model

Synergetic effect linked to inorganic matter?

Parameter to be considered: (K/Si)

$$\left(K/Si\right)_{BLEND} = \frac{\%_{BEECH} \cdot K_{BEECH} + \%_{WHEATSTRAW} \cdot K_{WHEATSTRAW}}{\%_{BEECH} \cdot Si_{BEECH} + \%_{WHEATSTRAW} \cdot Si_{WHEATSTRAW}}$$

Conclusions and outlook

- Conclusions
  - Torrefaction → ADDITIVE LAW
  - Steam gasification → NO ADDITIVE LAW → $(K/Si)_{BLEND}$ to be considered

- Outlook
  - Model biomass blends behaviour → inorganic matter influence in steam gasification → parameters
  - Other ratios
  - Other types of biomass

We are

in Grenoble!

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GRAZIE MILLE!! THANK YOU!!

MERCI BEAUCOUP!! MUCHAS GRACIAS!!

If you have any questions or want more details, please contact:

elvira.rodriguez@cea.fr

capucine.dupont@cea.fr